11. Force Application

Area Description

For the most part, the space aspects of Force Application are currently limited to ballistic missiles, which fly through space on sub-orbital trajectories, and to operational use of the C3 services and ISR products of space-based sensors and links. As we look to the future, space-based systems and space force mission options, such as active missile defense (BMD) may become increasingly important. Meanwhile, it is being recognized that space-based forces would add capabilities for deterrence and flexible response when time is absolutely critical, when risks associated with other options are too high, or when no other course of action is practical. At the same time, deployment of such systems is significantly limited by international treaties and U.S. national policy.

From a technology perspective, the sustainment of our intercontinental and sea-launched ballistic missile (ICBM, SLBM) assets is closely tied to the continuing development of solid rocket motor technologies for the Space Transportation mission. Ballistic missile technologies that are readily applied to other space missions include advanced propulsion techniques, solid state electronics (especially for guidance and navigation), advanced antennas, anti-jam GPS, plasma physics, high-temperature materials, reentry vehicle leading edges, thermal protection systems, sensor systems, smart fuze packages, desensitized ordnance, and high-speed projectiles.

Defensive force application via space comprises a family of theater and tactical missile defense (TMD) systems, directed energy systems, and the option for national missile defense (NMD). All are in various stages of definition or development, and all rely on space products and services for their effective operation.

As for offensive force application, the precision of conventional weapon strike is being enhanced by improvements in the accuracy and timeliness of targeting information to cruise missiles and strike aircraft from space-based assets. The concept labeled "sensor-to-shooter" captures the essence of

providing specifically required C4ISR information directly to a weapons (or other operational) platform in time to ensure mission success. While the engagement parameters may vary (e.g., for ordnance aimed at a fleeting target or a BMD intercept), a high degree of automation and link reliability is essential. Space-based systems, by their ubiquity and sensor capabilities, already play a key role in bringing this concept to maturity as the "cutting edge" of future force application.

Relevant space products (for strategic or tactical uses) include high-resolution imagery, ground MTI (GMTI) maps, and Digital Terrain Elevation Data (DTED). DTED and imagery can be used before hostilities to plan U.S. strike strategies and missions. Timely GMTI and SAR imagery can be integrated with strike aircraft targeting systems to provide battlefield dominance in a dynamic environment. Precise DTED of target areas can be uploaded to cruise missiles and correlated with an on-board altimeter for highly accurate all-weather midcourse and terminal guidance, which is autonomous and thereby resistant to both GPS jamming and covert techniques. After a strike, rapid battle damage assessment/information (BDA/BDI) can enable dynamic air tasking order updates, thus greatly compressing engagement and reengagement timelines.

Maturation of space-based radar capabilities is key to enabling rapid all-weather, day/night strike operations worldwide, from locating targets (GMTI/SAR), guiding weapons (DTED), to BDA (SAR). Additional focus is also needed on:

- Core structures, electronics, and propulsion
- Enabling technologies for space delivery of conventional systems, to include on-orbit support
- Development of relay mirrors to use with highpower laser sources, which could enable a ground-based laser (GBL) source or a longerterm space-based laser (SBL) capability for force application missions.

Mission Area Objectives

Current Technology Initiatives (Highlights of Current FYDP)

Funded basic research applicable to force application functions includes advanced materials, electromagnetics, nanotechnologies, propellants and propulsion technologies, electronics, high-performance computing, energy storage concepts, robust communication networks, software and knowledge-based systems, image processing, advanced solid state and electro-optical sensors, hyperspectral imagery, information fusion and visualization. At a more mature level, solid rocket

motor technologies from ICBM/SLBM sustainment activities that are being leveraged include:

- High-temperature materials
- Thermal management
- Plasma physics
- Solid propellants.

In addition, research continues into turbulence, drag, and neutral density variations in LEO, and into

artificial intelligence, ground-based space surveillance, hypersonics, aerospace structures, and plasma physics applicable to transatmospheric space vehicle design. Directed energy is being explored at optical and microwave wavelengths, and other research is focusing on impact and penetration concepts relevant to space debris and micrometeoroid threats.

The SBL Integrated Flight Experiment (IFX) program is currently funded to complete an on-orbit demonstration of integrated performance and

Enabling Technologies (Unconstrained)

- Autonomous, adaptive, self-training, real-time resource planning algorithms for tasking, mission planning/ management, target ID/ tracking and battlefield learning, and data processing, exploitation, and dissemination
- Improved precision time sources (10-ps timing accuracy) (atomic/laser clocks)
 - Network-centric communication synchronization techniques
- Dynamic target databases with improved data fusion and timely information delivery
- Very high capacity on-board computing and data storage
- Advanced "sensor-to-shooter" technologies to enable target neutralization and real-time assessment
- Human-system interfaces for information exploitation and decision-making
- Advanced ISR technologies to enable target acquisition and characterization
- Improved detection/ID of critical moving targets, both ground and air
- Improved characterization of hardened and deeply buried targets
- Increased sensor range and sensitivity technologies
 - Atmospheric and radiant background characterization, modeling, and processing
 - Improved atmospheric compensation and target classification algorithms for multispectral/hyperspectral image processing

lethality against ballistic missile targets in the FY12-13 time frame. Its four major technology areas for the near term are:

- Laser technologies
- Beam control
- Beam direction
- Acquisition pointing and tracking.

Selected additional project detail is tabulated in "Projected Applications," below.

- Advanced small, high-capacity, space-qualified cryocoolers
- Low/high-power laser atmospheric compensation and beam control technologies
- Advanced acquisition, pointing and tracking techniques
- High-energy laser technologies for ground/ space-based high-power lasers
- Space-based mirror technologies for high-power laser relay
- On-orbit laser servicing and replenishment of consumables
- Kinetic energy technologies
- Ballistic missile sustainment technologies to assure continued functionality of structure, propulsion, guidance, fuzing and payload subsystems
- Advanced weapon modeling and simulation (M&S) and test technologies
 - Non-destructive evaluation (NDE) technologies for prediction of rocket motor service life
- Advanced temperature/erosion/vibrationtolerant materials and technologies to assure missile/spacecraft reentry:
 - Advanced materials for solid rocket motors and reentry vehicle leading edges
 - Plasma effects technology to minimize signal blackout
 - Improved window/antenna materials for reentry systems.

Projected Applications

Solid Rocket Technologies

- Advanced and enhanced solid rocket motor technologies
- Advanced reentry vehicles
- Integrated geolocating guidance systems

Advanced AMTVGMTI for Battlefield Strike Operations

 Applications of space sensor imagery to offensive targeting

On-Orbit Support

- Reusable Launch
 Vehicles (e.g., SOV)
- On-orbit servicing (e.g., SMV)

Robust, tightly coupled GPS/INS systems for use with launch systems

Next-generation solid rocket technologies:

- Lower-size/weight/cost GPS/INS systems -
- Low-cost propellants, cases, liners, nozzles –

Advanced precision navigation instruments, nose cones, leading edges,

thermal protection systems, smart fuze packages, and high-speed projectiles

Maturation of:

- Space Webtemplateupdates -
- SBL and Full Power Relay Mirror System –
 Mobile GPS/INS-based range tracking
- and command destruct system –
- Advanced precision strike vehicle designs -
- GPS reacquisition after reentry plasma blackout –
 The strategic-grade Multi-Mission
 GPS/INS system –

Utility assessment of space sensor imagery, GMTI and DTED for battlefield strike operations

Resupply of space-based assets Storage of consumables

Leverage of Solid Rocket Technologies for Space Transportation

- Solid rocket technologies
- Low-cost/hazard propellants
- Post-boost control systems

Potential Offensive/Defensive Systems

- SBL demonstration
- Full-Power Mirror Relay System
- Precision targeting support
- KE systems

Opportunities for Partnering

The Air Force and Navy jointly fund Draper Laboratories' development of the Multi-Mission Inertial Navigation System (MMINS) for missile life extension and future replacement. Ohio University provides expertise to the Air Force for public safety certification of GPS/INS range instrumentation.

The Air Force and BMDO are jointly funding the SBL Integrated Flight Experiment (IFX) program, which will lead to on-orbit tests of a high-power laser system to demonstrate integrated operation, performance and lethality against a TBM target. This demonstration program could be extended to encompass force application missions.

